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Can Mild Bilateral Sensorineural Hearing Loss Affect Developmental Abilities in Younger School-Age Children?

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The research study was conducted for the purpose of examining the influence of mild bilateral sensorineural hearing loss (MBSNHL) on developmental abilities of younger school-age children. The sample encompassed 144 children with MBSNHL, aged 7.5–11 (M = 8.85). MBSNHL (20–40 dB HL) was identified by pure tone audiometry. The control group encompassed 160 children with normal hearing. The Acadia test of developmental abilities was used for assessment of developmental abilities. Although statistically significant differences between participants with MBSNHL and those with normal hearing were established in the majority of estimated developmental abilities domains, those differences do not indicate any significant delay in development of assessed abilities, except in the domain of auditory discrimination. The obtained results call for a systematic approach to children with MBSNHL in elementary schools.

Mild bilateral sensorineural hearing loss (MBSNHL) can be considered one of the categories of minimal hearing loss as defined by Bess, Dodd-Murphy, and Parker (1998). According to these authors, minimal hearing loss includes (a) MBSNHL—for pure tones at 0.5, 1.0, and 2.0 kHz with average hearing thresholds value from 20 to 40 dB HL, (b) high-frequency sensorineural hearing loss—hearing thresholds with results under 20 dB HL for two or more frequencies above 2.0 kHz, and (c) unilateral sensorineural hearing loss—hearing thresholds for pure tones at 0.5, 1.0, and 2.0 kHz, with average value ≥20 or hearing thresholds for pure tones >25 dB HL at two or more frequencies above 2.0 kHz for the ear where the loss was established and typical hearing thresholds in the contralateral ear.

According to current indicators, the prevalence of mild bilateral hearing loss is 10–15:1,000, whereas prevalence of unilateral hearing loss is significantly larger: 30–56:1,000 (Bess et al., 1998; Niskar et al., 1998). White and Munoz (2008) have suggested that overall prevalence of this phenomenon is likely 25 times infant screening data of 1.1–3.61 per 1,000 (Mehra, Eavey, & Keamy, 2009). The findings of one recent U.S. study indicated an increase in the prevalence of hearing difficulties among adolescents (Shargorodsky, Curhan, Curhan, & Eavey, 2010). With all forms considered, 15% of the student population likely has mild or moderate hearing loss (Dalton, 2013). A Serbian study on 1,165 elementary school children from grade two to grade four who have been audiologicaly examined uncovered a high percentage of children with minimal hearing loss. Results point to 8.1% of unilateral and 4.3% of mild bilateral hearing loss. The average value of hearing threshold for the right ear was 27.48 and 27.14 dB HL for the left ear (Đoković & Ostojić, 2009; Đoković, Slavnić, & Ostojić, 2003). Authors have highlighted the fact that children diagnosed with unilateral or bilateral hearing loss have been diagnosed for the first time as a part of this study. The children have had no additional support in school or adequate amplification and audiological rehabilitation up to this moment (Đoković et al., 2003).

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The first research studies on effects of minimal hearing loss on academic achievement and psychoeducational characteristics have appeared in the 1980s and have mostly been focused on unilateral hearing loss (Bess & Tharpe, 1986; Bess, Tharpe, & Gibler, 1986; Culbertson & Gilbert, 1986; Klee & Davis-Dansky, 1986). Results of these studies have grabbed the attention of experts concerning children with unilateral hearing loss. This population is characterized as one with a high academic and psychosocial risk. The study of Bess et al. (1986) has shown that 35% of children repeated at least one grade in school, whereas 13% of cases required additional educational support. Also, teachers reported behavioral problems in 20% of children with unilateral hearing loss. The rate of academic underachievement was 10 times higher in children with unilateral hearing loss compared to typical peers (Oyler, Oyler, & Matkin, 1988). Although most of the children in the Bess study had an IQ within the normal rage, those repeating grades had lower verbal IQ compared to those who achieved academic success (Bess et al., 1986). These results are in accordance with the study of Davis, Shepard, Stelmachowitz, and Gorga (1981), showing that in addition to lower verbal IQ, no statistically significant differences were found between children with unilateral hearing loss when speech and language development was concerned, compared to children with typical hearing (Klee & Davis-Dansky, 1986). However, other studies have shown speech and language deficits in children with unilateral hearing loss (Hallmo, Moller, Lind, & Tonning, 1986; Kiese-Himmel, 2002).

In addition to examining the effects of minimal hearing loss on speech and language development, psychoeducational characteristics, and academic achievement, Bess et al. (1998) have also made a functional assessment of children's health. They have used the Cooperative Information Project Adolescent Chart Method designed by Nelson, Wasson, Johnson, and Hays (1995). Their aim was to assess physical, emotional, and social functioning. Results have shown that children with mild bilateral and unilateral hearing loss had difficulties in areas of energy with increased stress, the need for social support, low self-esteem, and behavior problems (Bess et al., 1998).

A decade after the first studies of Bess et al. (1998) on unilateral hearing loss, studies on children with mild bilateral hearing loss appeared. Psychoeducational effects caused by mild bilateral hearing loss are similar to those caused by unilateral hearing loss. A study encompassing the population of school-aged children with unilateral and bilateral hearing loss has shown that 37% of these children had poor academic achievement and 8% needed additional school support (Bess et al., 1998). A study that was a part of the Third National Health and Nutrition Examination Survey has shown that among academic skills, the most affected were reading, grammar, punctuation, spelling, word analysis, and science. This study has shown that children aged 6–16 diagnosed with unilateral and mild bilateral hearing loss had a two times higher chance to be placed two standards deviations below average on standardized tests in math and reading compared to the typical population (Ross, Visser, Holstrum, & Kenneson, 2005). However, results of one study show no significant differences in level of achievement when children with mild bilateral hearing loss and typical intellectual abilities were compared to children aged 6–16 with normal hearing in the domain of receptive and expressive language, reading, behavior, and health-related quality of life (Wake et al., 2006). Apart from that, recent research points out that more than one third of children with unilateral and mild bilateral hearing loss experience difficulties with academic skills (Tharpe, 2008). Some authors consider that differences in the domain of academic and cognitive abilities in these children can occur as a consequence of difficulties in attending during classes (Teasdale & Sorensen, 2007).

Most (2004, 2006) came up with interesting results using SIFTER (Screening Instrument for Targeting Educational Risks) for examination of effects of the level of hearing loss on academic achievement in children attending regular schools. Although it was expected that children with unilateral and mild bilateral hearing loss would achieve better results or have better class participation than those with moderate and severe hearing loss, this was not the case. The children with greater level of hearing loss had better results on the following areas of SIFTER: communication, participation, and total score (Most, 2006). The reason for these unexpected results as pointed out by Kuppler, Lewis, and Evans (2013) can be

found in the fact that the children with greater hearing loss had support in schools, used hearing aids, or were enrolled in programs of early auditory rehabilitation. Similar results were found in a study by Antia, Jones, Reed, and Kreimeyer (2009), which has shown that the level of hearing loss correlated with achievements in reading only and not in math, language, writing, or academic status. Authors conclude that this does not mean that the level of hearing loss does not affect academic achievement. The effects of the level of hearing loss can be clearly seen when results of total academic achievement of children with hearing loss are compared with expected grade norms. Studies usually report underachievement. Conclusions based on the studies by Most (2006) and Antia et al. (2009) tell us that any level of hearing loss, even if mild, can lead to academic underachievement.

Longitudinal study that was conducted by Lieu, Tye-Murray, and Fu (2012) present data that indicate that children with unilateral hearing loss show progress over time in certain areas such as language and verbal IQ. However, no improvements in academic achievements were recorded. According to reports submitted by parents and teachers, Lieu et al. (2012) concluded that approximately 25% of children exhibit problematic behavior and have difficulties in learning.

In spite of the fact that according to the Serbian Health Care Law, systematic annual examination of children from birth to 18 years is provided, including hearing screening, children with unilateral and mild bilateral hearing loss are diagnosed late on and are rarely amplified or referred for audiological rehabilitation (Đoković et al., 2003). An additional difficulty is the fact that Serbia still has no legal regulation concerning neonatal auditory screening. This screening is usually carried out only within larger clinical centers. This means that a certain number of children with congenital hearing loss, especially those with unilateral and mild bilateral hearing loss, miss diagnosis at an early age. Most of the physicians are not familiar with the effects of unilateral or mild bilateral hearing loss on academic achievement. This has been reported for a number of other countries also (Carron, Moor, & Dhaliwal, 2006). A number of experts offering services within the primary pediatrics care have reported in questionnaires that they lacked knowledge in diagnostics and monitoring of children with congenital hearing loss (Carron et al., 2006). Also, a study by Neault (2005) shows that even when minimal hearing loss is identified, a number of health care experts either show no greater concern or are unsure of therapy and audiology treatment options (Neault, 2005). Therefore, these children often do not receive adequate and timely treatment (McKay, Gravel, & Tharpe, 2008).

The goal of this study was to examine cognitive and academic abilities in children with mild bilateral hearing loss who were late identified and did not have access to hearing aids. This study population offers a unique opportunity to explore the impact of untreated mild bilateral hearing loss on the developmental abilities of young school-age children. Based on the extant literature, we hypothesized that these children would demonstrate difficulties in cognitive and academic outcomes compared to peers with normal hearing.

Method

Participants

The sample encompassed 144 children of both genders (79 males and 65 females) with MBSNHL from Belgrade, aged 7.5–11 (M = 8.85), and second to fourth grade level of elementary school. MBSNHL (20–40 dB HL) was identified by pure tone audiometry. Children were examined as part of regular annual health checkups. These examinations are regulated by the Health Insurance Law (Health Insurance Law, Article No. 35). The children had otoscopic examination, screening pure tone audiometry, and tympanometry. Hearing was examined for 0.5, 1, 2, and 4 kHz pure tone air and bone conduction threshold with headphones (standard TDH 39/41) by regulated standards (American National Standards Institute [ANSI], 1991). Screening level was 20 dB HL. Participants were selected if MBSNHL was suspected, and they were referred for additional audiological examination to establish thresholds and configuration of the hearing loss. Children with conductive hearing loss or other developmental disorders or chronic illnesses were excluded. Also, participants with unilateral sensorineural hearing loss were not included in the sample. If they met the study criteria, the participants were sent to an additional audiologic examination in order to establish their hearing status. Following this examination, 163 participants were sent in total. MBSNHL was diagnosed for hearing threshold

of 21–40 dB HL, with an air-bone gap of <10 dB HL for any frequency, bilaterally. Children were tested under headphones in a quiet, controlled environment. Hearing thresholds were later confirmed in an audiological test suite. Hearing children passed the hearing screening test, administered at 20 dB HL, as described above. After thorough examination, 144 participants were left in the sample, and 19 were removed due to the conductive component in their hearing loss. The control group, matched to participants with MBSNHL in age ($\chi^2 = 0.694$, $df = 1$, $p = .405$) and gender ($\chi^2 = 0.310$, $df = 2$, $p = .856$), encompassed 160 children with normal hearing, aged 7.5–11 ($M = 8.47$).

Instruments and Procedures

Data on age and intellectual abilities have been extracted from official school documentation. The study used data collected by the research team for assessment of visual functions, with team leader's permission. The Lighthouse Near Vision Test has been used as a screening test of visual acuity.

Hearing Assessment

Repeated pure tone audiometry examination was carried out in a sound proof room by three audiologists with certificates of the Serbian Special Education Society—the Audiology Group. All the participants were examined using Hughson-Westlake method of audiological testing. A two-channel clinical audiometer Maico MA 52 was used, calibrated according to ANSI S3.6-1996 standards. Telephonics TDH 39 headphones were also used, and bone threshold was examined by vibrator B 71. We used contralateral masking with white noise 10 dB HL below stimulus intensity.

Assessment of Developmental Abilities

The Acadia test of developmental abilities (Atkinson, Johnston, & Lindsay, 1972), translated and adapted in 1985 in Croatia (Novosel & Marvin-Cavor, 1985), additionally adapted and standardized in Serbia (Gligorović et al., 2005) was applied for the assessment of developmental abilities. The Acadia test of developmental abilities consists of 13 subtests, intended for assessment of diverse abilities and skills necessary for development of academic skills in elementary school. The Acadia test demonstrated good internal consistency among typically developing children ($\alpha = 0.86$), and each of the 13 Acadia's subscales demonstrated adequate internal consistency (α ranged from 0.84 to 0.93).

The test can be implemented individually or within groups. Given that it is not a type of test that requires speed, it can be adapted to individual rhythms of each child. Perceptual functions, verbal abilities, and nonverbal abilities are assessed. The test was administered by trained special educators who have also interpreted the results and were blind to the fact that some children were diagnosed with MBSNHL.

The children were diagnosed with MBSNHL for the first time as a part of this study, meaning they had no additional support in school or received audiology rehabilitation or amplification.

Data Analysis

Measures of central tendency (arithmetic mean), measures of variability (*SD* and variance), and range of results (minimum and maximum) were used for the basic statistical data processing. One-factorial analysis of variance (ANOVA), multifactorial ANOVA (MANOVA), two-factorial ANOVA, and χ^2 test have been used for determining the relations of significance between variables.

Results

The aim of the study was to examine the influence of MBSNHL on developmental abilities of children. Bearing in mind that the Acadia test is a paper–pencil test, in order to avoid errors in result interpretation due to potential multiple sensory difficulties, the relation between MBSNHL and visual acuity was analyzed, but no statistical significance was found ($\chi^2 = 4.335$, $df = 2$, $p = .113$). Statistically significant differences in prevalence of MBSNHL for either age ($\chi^2 = 4.612$, $df = 2$, $p = .100$) or gender ($\chi^2 = 0.652$, $df = 1$, $p = .419$) were not found.

MBSNHL and Perceptual Functions

Statistically significant influence of MBSNHL on variables grouped in a unique set of perceptual functions (Wilks' $\lambda = 0.981$; $F(5) = 4.554$, $p < .000$) was determined (Table 4).

Statistically significant differences between participants with MBSNHL and those with normal hearing in the domains of auditory discrimination, auditory memory, visual discrimination, and sensory integration (audiovisual association) were determined by analyzing the influence of the MBSNHL on scores of subtests that assess perceptual functions.

In the domain of visual memory, results of MANOVA revealed no significant difference between groups (Table 1).

Two-factorial ANOVA results suggested significant differences between groups in the domains of auditory discrimination ($F(1) = 7.112$, $p = .008$) and auditory memory ($F(1) = 4.230$, $p = .040$) were determined by implementation of two-factorial ANOVA.

MBSNHL and Verbal Abilities

Statistically significant influence of MBSNHL on verbal abilities variables was determined (Wilks' $\lambda = 0.985$; $F(3) = 5.897$, $p = .001$; Table 5).

Statistically significant differences between participants with MBSNHL and those with normal hearing in the domains of concept formation (subtest *Concept Formation*) and morphosyntactic abilities (subtest *Automatic Language*, *Language Treasure*) were determined by analyzing the influence of MBSNHL on subtest scores that assess verbal abilities.

In the domain of lexical abilities (subtest *Acquired Language Treasure*), results of MANOVA revealed no significant difference between groups (Table 2).

Two-factorial ANOVA results suggested significant differences between groups in the developmental dynamics of verbal abilities and in the domains of verbal concept formation (subtest *Concept Formation*; $F(1) = 11.044$, $p = .001$) and morphosyntactic abilities (subtest *Automatic Language Treasure*; $F(1) = 4.230$, $p = .040$) were determined by implementation of two-factorial ANOVA.

MBSNHL and Nonverbal Abilities

Statistically significant influence of MBSNHL on nonverbal ability variables was determined (Wilks' $\lambda = 0.974$; $F(5) = 6.126$, $p < .000$; Table 6).

Statistically significant differences between the participants with MBSNHL and those with normal

Table 1 Assessment of perceptual functions

Ability	Subtest	Description
Perceptual functions	Auditory discrimination	It consists of 20 tasks that test the ability to distinguish mainly one-syllable words and nonwords that sound similar. One point is awarded for each correct answer.
	Auditory memory	In the first part of the test, a child has to memorize and write down numerous sequences of increasing number of stimuli. In the second part, a child has to recognize a number and its place in a sequence (verbal working memory), and in the third part to memorize and write down as many words as possible in increasing sequences. It consists of 15 tasks, and assessment depends on their complexity. The maximum number of points is 20.
	Visual discrimination	It consists of 20 tasks in which a child is expected to choose one out of four options based on a given model. The first part consists of drawings, whereas the second and the third part consist of words arranged from simple to more complex ones. One point is awarded for each correct answer.
	Visual memory	After seeing the model, a child has to choose one of the given answers or draw the appropriate shape. It consists of 10 tasks. Two points are awarded for each correctly completed task.
	Audiovisual association	The subtest consists of 3 parts. In the first part, a child is expected to choose a picture that matches the sentence uttered by the examiner. In the second part, a child is expected to recognize the word uttered by the examiner out of four given words, and in the third part to match words with pictures whose pronunciation rhymes. It consists of 20 tasks. One point is awarded for each correct answer.

hearing in the domains of visuomotor coordination, constructive praxia (subtest *Shapes Drawing*), nonverbal reasoning (subtest *Visual Association*), and concept formation in the nonverbal domain (subtest *Sequence and Coding*) were determined by analyzing the influence of the MBSNHL on subtest scores that assess nonverbal abilities (MANOVA). In the domain of the representational dimension of drawings (subtest *Drawing*), the differences between the participants with MBSNHL and those with normal hearing were not established (Table 3). Significant difference in the developmental dynamics of nonverbal abilities between the participants with MBSNHL and the participants with normal hearing in the domains of nonverbal reasoning (subtest *Visual Association*; $F(1) = 20.014$, $p < .000$) and nonverbal concept formation (subtest *Sequence and Coding*; $F(1) = 6.687$, $p = .010$) was determined by the implementation of two-factorial ANOVA.

Categories of the ACADIA Test Results

The subtest scores of the ACADIA test are ranked according to age norms and grouped into three categories: age-appropriate achievements (mean ± 1 *SD*), achievements deviating one standard deviation (1 *SD*), and achievements deviating two or more standard

Table 2 Assessment of verbal abilities

Ability	Subtest	Description
Verbal abilities	Concept formation	It consists of four sets of tasks the completion of which requires identifying, comparing, and naming characteristics, knowing concept relations, and classifying and organizing lexemes into subordinate and superior classes. Drawings and verbal instructions are combined in the subtest. It consists of 20 tasks. One point is awarded for each correct answer.
	Acquired language treasure	It consists of 20 tasks divided into three sets. In the first set of tasks, a child is expected to recognize a picture or a written word orally presented by the examiner. In the second set of tasks, a child is required to make a choice from a number of written words as instructed by the examiner. In the third set of tasks, the participants confirms or denies the veracity of certain statements. One point is awarded for each correct answer.
	Automatic language treasure	It consists of 20 tasks in which the participants have to choose a word or a set of words to complete the sentence uttered by the examiner. One point is awarded for each correct answer.

Table 3 Assessment of nonverbal abilities

Ability	Subtest	Description
Nonverbal abilities	Visuomotor coordination and sequencing	It consists of 10 tasks that test the ability to follow a marked path between different types of lines (concentric circle, square, triangle, etc.) and complete the shapes. A certain number of points are awarded for each task, counting mistakes, and the maximum number of points is 20.
	Shapes drawing	It includes 20 models that a child has to copy. One point is awarded for each correct answer.
	Visual association	It consists of 10 tasks. In the first part of the test, a child is expected to establish a functional relationship between the given model and one of the given options (e.g., ear and a receiver), and in the second part to reconstruct a whole from elements. Assessment depends on the complexity of tasks, and the maximum number of points is 20.
	Drawing	A child is expected to draw a man standing under a tree, next to a house. Assessment depends on the accuracy of proportions, the number of details, and correlation between the set elements. The maximum number of points is 20.
	Sequence and coding	It consists of 20 tasks. In the first part, a child is expected to choose a geometric shape, a number or a word that continues the given sequence, and in the second part to discover and apply the principle of forming words by decoding numbers into letters. One point is awarded for each correct answer.

Table 4 Mild bilateral sensorineural hearing loss (MBSNHL) and perceptual functions

Perceptual function	Hearing	Mean	*SD*	*F*(1)	*p*	Partial η^2
Auditory discrimination	MBSNHL	14.61	5.430	15.503	**.000**	0.123
	Normal hearing	16.31	4.752			
Auditory memory	MBSNHL	10.22	3.235	12.875	**.000**	0.091
	Normal hearing	11.25	3.243			
Visual discrimination	MBSNHL	16.65	3.572	5.132	**.024**	0.034
	Normal hearing	17.37	3.550			
Visual memory	MBSNHL	17.47	2.634	1.996	.158	0.002
	Normal hearing	17.81	2.728			
Audiovisual association	MBSNHL	17.38	2.517	4.819	**.028**	0.022
	Normal hearing	17.84	2.333			

Note. Statistically significant values are marked in bold.

Table 5 Mild bilateral sensorineural hearing loss (MBSNHL) and verbal abilities

Verbal abilities	Hearing	Mean	*SD*	*F*(1)	*p*	Partial η^2
Concept formation	MBSNHL	13.61	3.013	12.614	**.000**	0.087
	Normal hearing	14.54	2.937			
Acquired language treasure	MBSNHL	16.62	2.870	2.771	.096	0.002
	Normal hearing	17.03	2.755			
Automatic language treasure	MBSNHL	14.71	4.324	12.643	**.00**	0.088
	Normal hearing	16.01	4.067			

Note. Statistically significant values are marked in bold.

Table 6 Mild bilateral sensorineural hearing loss (MBSNHL) and nonverbal abilities

Nonverbal abilities	Hearing	Mean	*SD*	*F*(1)	*p*	Partial η^2
Visuomotor coordination	MBSNHL	12.26	4.098	7.311	**.007**	0.056
	Normal hearing	13.25	4.091			
Shapes drawing	MBSNHL	12.69	4.326	5.991	**.015**	0.039
	Normal hearing	13.59	4.098			
Visual association	MBSNHL	14.69	3.923	15.438	**.000**	0.130
	Normal hearing	16.28	3.479			
Drawing	MBSNHL	14.62	3.133	0.932	.334	0.001
	Normal hearing	14.87	2.859			
Sequence and coding	MBSNHL	14.17	3.076	12.291	**.000**	0.088
	Normal hearing	15.17	3.196			

Note. Statistically significant values are marked in bold.

deviations (2 *SD*) from the mean achievements. Results 1 *SD* below expected indicate some difficulties, and deviation of two or more *SD* indicates specific difficulties in a given domain. Deviation of 2 *SD* from age norms in one of the subtests or overall results of ACADIA test indicates the need for the child to be involved in a secondary prevention program. If that program is estimated as inappropriate, tertiary prevention, which implies creation of an Individual Educational Program, would be involved.

According to the age-norm deviation criterion, statistically significant difference between participants with MBSNHL and those with normal hearing was determined only for the *Auditory Discrimination* subtest ($\chi^2 = 9.005$, $df = 2$, $p = .011$). Namely, 22.9% of the participants with MBSNHL deviate from age norms in 1 or 2 *SD* (8.3% one *SD* and 14.6% two *SD*). In the group of participants with normal hearing, 12.5% deviated from the age norms in 1 or 2 *SD* (5.1% one *SD* and 7.4% two *SD*).

Statistically significant difference of general scores between the participants with MBSNHL and participants with normal hearing ($F(1) = 21.345$, $p < .000$) was determined using ANOVA. Significant difference in developmental dynamics of perceptual functions, verbal abilities, and nonverbal abilities (expressed as the total score on the Acadia test) between participants

with MBSNHL and those with normal hearing ($F(1) = 11.716$, $p = .001$; Figure 1) was determined using two-factorial ANOVA.

Increasing discrepancy among test results between participants with MBSNHL and normal hearing ones is noticed with age and education level. According to the criterion of deviation from age norms, there was no statistically significant difference ($p > .05$). The effect size (Cohen's d) for this difference (−0.41), however, shows that this is just a small to moderate effect.

Discussion

In the domain of perceptual functions, the participants with MBSNHL achieve significantly lower results than those with normal hearing ($p < .000$). Analyzing single variables, it was established that the achievements of the participants with MBSNHL are significantly lower in the domains of auditory discrimination, auditory memory, visual discrimination, and sensory integration (audiovisual association). Significant difference in the developmental dynamics of perceptual functions between participants with MBSNHL and those with normal hearing was established in the domain of auditory discrimination and auditory memory. In the domain of visual memory, the differences between the participants with MBSNHL and normal hearing ones were not determined.

Our findings confirm the results of previous research, whereby children with MBSNHL have poorer phonological discrimination and short-term phonological memory than children with normal hearing (Briscoe, Bishop, & Norbury, 2001; Norbury, Bishop, & Briscoe, 2001). Lower results of participants with MBSNHL in the domain of visual discrimination are seemingly unexpected. However, it is possible that children with MBSNHL are primarily focused on understanding the audiovisual contents, dominant in teaching conditions/educational circumstances, somewhat neglecting the visual ones, which leads to reduction of quality in visual experiences and visual integration. In that context, significantly lower results of children with MBSNHL in the domain of sensory integration are understandable. Unlike children with severe hearing or visual impairments, which compensate the deficiency of sensory input of one sensory modality with another, children with MBSNHL may not develop adequate compensatory strategies. They may try to compensate the impaired sensory modality at the expense of another sensory modality and sensory integration by investing additional effort and attention. Further, low energy researching concept used double task paradigm for assessment of errors in hearing in school-age children with MBSNHL. This research proved that children with MBSNHL show great energy waste during the hearing task. Low energy

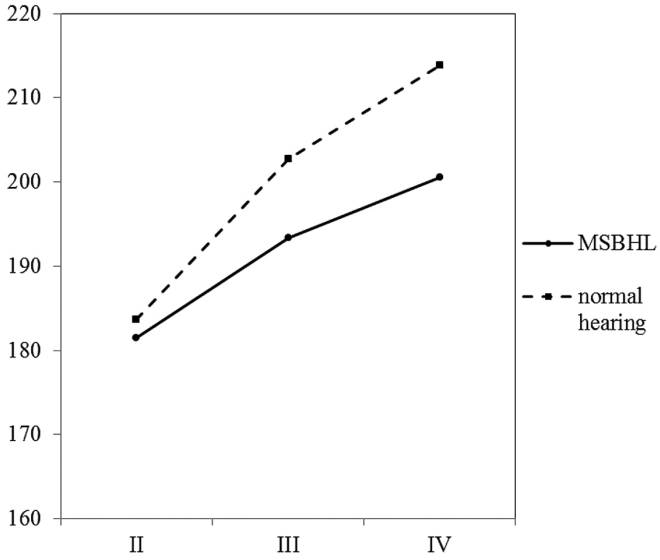

Figure 1 General scores of the Acadia test in participants with mild bilateral sensorineural hearing loss and normal hearing 96 × 84 mm (600 × 600 DPI).

and exhaustion can present problems in class behavior (Hicks & Tharpe, 2002).

In the domain of verbal abilities, the participants with MBSNHL achieve significantly lower results than those with normal hearing ($p = .000$). Analyzing single variables, it was determined that the achievements of the participants with MBSNHL are significantly lower in the domains of concept formation (subtest *Concept Formation*) and morphosyntactic abilities (subtest *Automatic Language Treasure*). Significant difference in the developmental dynamics of verbal abilities between the participants with MBSNHL and participants with normal hearing is established in the domains of verbal concept formation (subtest *Concept Formation*) and morphosyntactic abilities (subtest *Automatic Language Treasure*). In the domain of lexical abilities (subtest *Acquired Language Treasure*), the differences between the participants with MBSNHL and those with normal hearing have not been noticed. The study by Koehlinger, Owen Van Horne, and Moeller (2013) concluded that children who are hard of hearing (HH) have lower results when grammar is concerned compared to their normal peers. These authors recommend close monitoring of language development in HH children due to increased risks for language learning.

Data on the development of verbal abilities and communication in children with MBSNHL are inconsistent and frequently contradictory (Moeller, Tomblin, Yoshinaga-Itano, McDonald, & Jerger, 2007).

Research in the domain of concept categorization does not point to significant differences between children with normal hearing and children with diverse degree of hearing loss (mild to severe), but it is emphasized that the achievements decrease with the severity of hearing impairment. Authors have considered the connection with the quality and quantity of auditory input (Jerger et al., 2006). Our results indicate that children with MBSNHL achieve significantly lower results in the domain of verbal concept formation than their peers with normal hearing.

Assessing the morphology of words in children with mild to moderate hearing loss, children with specific language impairment (SLI), and children with normal hearing, it was established that children with hearing loss achieve better results than children with SLI and also that the mean value of their results does not significantly differ from achievements of children with normal hearing (Norbury et al., 2001). Findings of a relatively small number of studies that have been involved in research of syntactic development in children with mild to severe hearing loss are not consistent. Several studies have not shown significant differences in syntactic abilities of children with hearing loss and their peers with normal hearing (Briscoe et al., 2001), whereas others report that the results of children with mild to moderate hearing loss (mean age: 9 years) are equal to children with normal hearing, but of a younger chronological age on standardized grammar comprehension tests (Gilbertson & Kamhi, 1995). One of the studies shows that the number of grammatical errors is associated with the severity of hearing loss. The most frequent ones are the complex syntax errors, verb structure errors, connected morphemes, and pronouns. Based on the acquired results, the authors consider that general developmental patterns in the domain of syntax in children with hearing loss and children with normal hearing are similar, except for verb omission (Elfenbein, Hardin-Jones, & Davis, 1994). Our results indicate that children with MBSNHL achieve significantly lower results in the domain of morphology and syntax than their peers with normal hearing.

Some authors believe that even the mildest hearing loss can lead to delay in lexical development (glossary, vocabulary) (Davis, Elfenbein, Schum, & Bentler, 1986; Wake, Hughes, Poulakis, Collins, & Rikards, 2004), whereas others conclude that there are no significant differences between most school-age children with mild to moderate hearing loss and children with normal hearing in the domain of vocabulary (Gilbertson & Kamhi, 1995; Plapinger & Sikora, 1995). Recent studies discuss the delay in the development of early receptive and expressive vocabulary in younger children with hearing loss (Mayne, Yoshinaga-Itano, Sedey, & Carey, 1998). The results of a longitudinal study of early word learning in infants with hearing loss and normal hearing suggest that delay in the phonetic and phonological development influences the vocabulary of younger children with mild and moderate hearing loss (Moeller et al., 2007). Our results show that children with MBSNHL do not manifest more significant difficulties in the domain of vocabulary compared to their peers with normal hearing.

In the domain of nonverbal abilities, the participants with MBSNHL achieve significantly lower results than those with normal hearing ($p < .000$). Analyzing individual variables, it was determined that the achievements of the participants with MBSNHL are significantly lower in the domains of visual-motor coordination, visuoconstructive ability (subtest *Shapes Drawing*), nonverbal reasoning (subtest *Visual Association*), and concept formation in the nonverbal domain (subtest *Sequencing and Coding*). Also, significant difference in the developmental dynamics between the participants with MBSNHL and those with normal hearing in the domains of nonverbal reasoning (subtest *Visual Association*) and nonverbal concept formation (subtest *Sequencing and Coding*) was determined. In the domain of representational drawing (subtest *Drawing*), the differences between the participants MBSNHL and normal hearing ones were not found.

It is possible that significantly lower results on the majority of subtests that assess nonverbal abilities lie on the aforementioned focus of children with MBSNHL on understanding auditory-verbal contents, which leads to the reduction in quality of visual experience and visual integration. These are essential for successful nonverbal task solving.

Deviation from age norms for 2 *SD* on subtests that assesses auditory discrimination has a twice higher occurrence for participants with MBSNHL compared to participants with normal hearing. Statistically significant difference of the deviation of age norms between the participants with MBSNHL and those with normal hearing was not established on other subtests of the Acadia test. This means that, although statistically significant differences between participants with MBSNHL and normal hearing ones were established in the majority of assessed domains of developmental abilities, these differences were not greater than 2 *SD* below the normative mean. It is possible that perceptual difficulties of isolated verbal stimuli, which are founded on the ability to recognize distinctive sound features, are at the center of lower achievements of children with MBSNHL in the rest of the domains. The potential reasons for such results are that children with MBSNHL often remain unrecognized and therefore not included in intervention programs. It is not uncommon that these children are misdiagnosed as children with SLI, which leads to inappropriate treatment. The situation becomes significantly complicated when children with mild bilateral sensorineural bilateral hearing loss find themselves in classroom conditions that are inadequate for this population of children due to constant presence of ambient noise and sound reverberation. Also, standard teaching methods and methodological procedures are inappropriate for children with mild bilateral sensorineural bilateral hearing loss and this can further influence their academic achievements.

It needs to be noted that this study had its limitations as it did not consider socioeconomic status of families and its influence on academic achievement of children with MBSNHL.

Conclusion

The research was conducted with the purpose of establishing the influence of MBSNHL on perceptual functions, verbal abilities, and nonverbal abilities of younger school-age children.

The results of children with MBSNHL in all the assessed domains (perceptual functions, verbal abilities, and nonverbal abilities) are statistically lower than the results of children with normal hearing. Statistically significant differences between participants with MBSNHL and participants with normal hearing were determined on the majority of subtests of the Acadia test. According to the age-norm deviation criterion in 1 and 2 *SD*, statistically significant difference between the participants with MBSNHL and those with normal hearing was determined on the subtest that assesses auditory discrimination. There was no statistically significant difference in overall achievements (general score) on the Acadia test of developmental abilities between participants with MBSNHL and those with normal hearing.

Although the achieved results do not suggest greater than 2 *SD* delay in the development of perceptual functions, verbal abilities, and nonverbal abilities, the result do suggest significant differences in performance compared to matched age-mates with whom these children are competing in school. This suggests the need for a systematic approach to management of children with MBSNHL. We consider the

approach suggested by Tharpe (2008) to be the most conceptually acceptable, and it consists of family counseling, etiological evaluation, acoustic modification, monitoring of language–speech development, audiological monitoring, and functional hearing assessment (Tharpe, 2008). Based on the results of assessment of strengths and weaknesses, a child with MBSNHL, if necessary, can be included in the individual special education and speech therapist treatment, and assistive technology implementation programs can be concluded as well. Also, it would be necessary to create systems and strategies that would significantly help children with MBSNHL to properly understand in-class lectures. These strategies are composed of three levels of intervention: modifications of their environment (adaptation of classrooms to decrease background noise), technological modifications (implementation of audio technology such as personal frequency modulation systems and FM systems in free sound field), and educational modifications (instructions for teachers on how to interact with MBSNHL children).

Conflicts of Interest

No conflicts of interest were reported.

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